PATENT
5018/ISM/MCVD/BG
7828.7056

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	)	Examiner: not assigned
Tepman, et al.	)	
Serial No.: 10/074,854	)	Art Unit: 2812
Filing Date: February 11, 2002	)	

For: VARIABLE FLOW DEPOSITION APPARATUS AND METHOD IN SEMICONDUCTOR SUBSTRATE PROCESSING

PRELIMINARY AMENDMENT

Assistant Commissioner of Patents
Washington, D.C. 20231

Dear Sirs:

Prior to issuing a first action in the above-referenced application, please enter and consider the following amendments:

IN THE DRAWINGS:

Please amend Figure 2 as shown in red in the attached drawings.

IN THE SPECIFICATION:

Please replace paragraphs 0014, 0016, 0019, 0020, and 0022-26 with the following rewritten paragraphs:

[0014]
Fig. 1 is a cross sectional view of a single substrate ALD chamber in accordance with aspects of the present inventions.

Figs. 2A and 2B form a schematic chart (as indicated in Fig. 2) illustrating a process in accordance with aspects of the present inventions using the chamber of Fig. 1.

Fig. 3 is an enlarged view of the nonsealing flow restrictor of Fig. 1.

Fig. 4 is a schematic view of the chamber body top of Fig. 1.

Fig. 5 is a cross sectional view of a single substrate ALD chamber in accordance with an alternative embodiment.

Fig. 6 is an enlarged view of the nonsealing flow restrictor of Fig. 5.

[0016] Figures 2A and 2B illustrate in schematic form a typical process 120 for depositing material on to a substrate such as the substrate 108 using the chamber 100. As explained in greater detail below, the present inventions have particular applicability to deposition processes such as atomic layer depositions in which many very thin layers are deposited in rapid succession onto the substrate. As indicated generally at 122, a typical process is initiated by admitting a substrate into the chamber though a slit valve or other suitable substrate port 124 (Fig. 1) and onto the support surface 106 for processing. A heater 128 may be provided within the substrate support 102 to heat the substrate 108, depending upon the particular deposition process.

[0019] For example, prior to admitting or during the admission of deposition gas, the exhaust flow restrictor 154 may be closed (step 170 of Figs. 2A and 2B) to facilitate achieving an adequate deposition gas pressurization level in the chamber during the deposition process. As indicated at 172 in Figs. 2A and 2B, the closing of the exhaust flow restrictor 154 initiates a "pressure cycle" in which the pressure of the chamber is increased for deposition. Thus, following closing of the exhaust flow restrictor 154 a processing gas such as a deposition gas is admitted (or continued to be

admitted) into the chamber through the gas inlet 140 as represented by step 173 in the process of Figs 2A and 2B. Because the flow restrictor 154 is closed, the pressure in the chamber will rise. However, because the exhaust flow restrictor 154 in the embodiment of Fig. 1 is not a sealing type flow restrictor, it is anticipated that some deposition gas may escape through the closed flow restrictor 154 during the deposition process. However, as long as the flow rate through the closed flow restrictor 154 is less than the flow rate through the inlet flow valve 141, it is believed that the pressure in the chamber can rise to the desired level notwithstanding leakage through the exhaust flow restrictor 154. In a preferred embodiment, the flow rate through the closed flow restrictor is within a range of 0 – 100 sccm (standard cubic centimeter per minute) at a pressure in the range of 10 Torr to 300 Torr. Thus, the flow restrictor can be a near sealing flow restrictor which has a relatively low flow rate in the "closed" position.

[0020] Once the desired pressure level has been achieved, the flow valve of the deposition gas inlet 140 may be closed. For some deposition processes, it may be desirable to permit the substrate 108 to soak in the deposition gas atmosphere (step 174, Figs. 2A and 2B) in the interior of the chamber for a length of time following the closing of the gas inlet to ensure an adequate deposition thickness. To ensure adequate deposition gas pressure during the soaking period, the deposition gas pressure may be raised prior to closing the gas inlet to a level which would accommodate some leakage through the exhaust flow restrictor during the soaking period. In one embodiment, the pressure may rise to a level of 300 Torr, for example. Thus, although the deposition gas pressure may fall somewhat during the soaking period because of some leakage through the nonsealing exhaust flow restrictor, the deposition gas pressure at the end of the soaking period may still be sufficiently high to ensure a satisfactory deposition. In a preferred embodiment, the deposition gas pressure for a typical deposition gas may fall to a level in a range of 5 – 30 Torr.

[0022] Once the substrate has soaked in the deposition gas for a sufficient length of time to deposit the desired thickness of deposition material, the pressure cycle

172 may be ended by opening the exhaust flow restrictor 154 (step 180, Figs. 2A and 2B) as shown in Fig. 1 to permit the residue gasses to be readily exhausted from the chamber interior during a "purge cycle" as indicated at 182 in Figs. 2A and 2B. In this open position, the exhaust flow restrictor 154 preferably has sufficient conductance to permit rapid exhaustion of the residue gasses. In a preferred embodiment, the non-sealing flow restrictor 154 has a conductance in the range of 10 –20 slm (standard liter per minute) in the open position. By comparison, the conductance of the near sealing flow restrictor 154 in the closed position illustrated in Figs. 2A and 2B is preferably much smaller and is preferably close to zero but it is anticipated that the conductance will be somewhat greater than zero because the flow restrictor is a non-sealing flow restrictor. In a preferred embodiment, the near sealing flow restrictor 154 has a conductance in the range of 0 - 100 sccm in the closed position.

[0023] To facilitate exhausting the residue gasses from the chamber, a pump 200 may be coupled to an outlet port 202 of the exhaust outlet 150 as shown in Fig. 4. In addition one or more purge gasses may be admitted into the chamber as indicated in step 204 (Figs. 2A and 2B), to drive the residue gas from the chamber interior as the pump 200 pumps the gasses through the exhaust flow restrictor 154, through the exhaust passageway 152 and out of the chamber through the outlet port 202. Once the chamber has been sufficiently purged, a different reactant or deposition gas may be admitted to deposit another thin layer.

[0024] In the process of Figs. 2A and 2B, there is a plurality of pressure cycles 172, each followed by a purge cycle 182, to sequentially deposit a plurality of layers onto a substrate before the substrate is removed from the chamber. In each pressure cycle 172, the non-sealing flow restrictor 154 is closed and a process gas such as a deposition gas is admitted. After a layer has been deposited, the non-sealing flow restrictor is opened and residue gasses are discharged in the subsequent purge cycle 182. The process gas or gasses may be the same in each pressure cycle or may change, depending upon the desired process.

[0025] In the embodiment of Figs. 2A and 2B, a first reactant gas is admitted in the gas admission step 173 of the first pressure cycle 172. After the subsequent purge cycle 182, a pressure cycle 206 follows which is similar to the pressure cycle 172 except that following the closing of the exhaust flow restrictor (step 208) a second, different reactant gas is admitted in an admission step 210 of this next pressure cycle 206. During the pressure cycle 206, the second reactant is deposited onto or otherwise reacts with the first reactant deposited in the prior pressure cycle 172 (step 212) to form another thin layer on the substrate. Examples of deposition materials in a second pressure cycle include nitrogen, oxygen or silicon which can react with the previously deposited material to form a nitride, oxide or silicide, respectively.

[0026] Following each pressure cycle 206, a purge cycle 214 similar to the purge cycle 182, opens the non-sealing exhaust flow restrictor 154 (step 216) to purge the undeposited second reactant from the chamber using a purge gas (step 218). The pressure cycles 172 and 206 alternate in this manner, depositing alternating layers of the first and second reactants, each pressure cycle being followed by an associated purge cycle 182, 214, until the desired film thickness has been deposited (or the film processing is otherwise complete). After the final purge cycle 214, the slit valve 124 is opened and the substrate is removed from the chamber as shown in step 220 of Figs. 2A and 2B. Because of the rapid opening and closing capabilities of the flow restrictor 154, it is believed that the combined total of the pressure cycle and the purge cycle may be in a range of 5 - 20 seconds and more typically 10 seconds for many applications. However, the exhaust flow restrictor is suitable for substantially shorter cycles of .5 seconds or less, depending upon the application. Other pressure cycles may be 5 seconds or 3 seconds or less, depending upon the application.

REMARKS

Claims 1-50 are in the case.

In response to the Notice to File Corrected Application Papers, submitted for the Examiner's approval is an amendment to Figure 2 as indicated in red on the attached copy of Figure 2. In order to comply with the drawing requirements set forth in the Notice, Figure 2 has been divided into two figures, Figure 2A and 2B. Anticipating the Examiner's approval for this drawing amendment, formal drawings incorporating the amendment are being filed concurrently herewith in response to the Notice to File Corrected Application Papers. In addition, amendments have been made to the specification to conform the specification with the formal drawings, as amended.. Examination on the merits is requested.

Attached hereto is a marked-up version of the changes made to the specification by the current amendment. The attached page is captioned "Version with markings to show changes made."

Please direct all correspondence in this case to:

Patent Counsel
APPLIED MATERIALS, INC.
Post Office Box 450A
Santa Clara, California 95052

Please direct all telephone calls to the undersigned.

Respectfully submitted,

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Reg. No. 28,858
Customer No. 24033
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Date: 7/9/02

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail on the date indicated above and is addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231.

William K. Konrad (Date) 7/9/02

VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the specification:

Paragraphs 0014, 0016, 0019, 0020, and 0022-26 have been amended as follows:

[0014]
Fig. 1 is a cross sectional view of a single substrate ALD chamber in accordance with aspects of the present inventions.

~~Fig. 2 is~~ Figs. 2A and 2B form a schematic chart (as indicated in Fig. 2) illustrating a process in accordance with aspects of the present inventions using the chamber of Fig. 1.

Fig. 3 is an enlarged view of the nonsealing flow restrictor of Fig. 1.

Fig. 4 is a schematic view of the chamber body top of Fig. 1.

Fig. 5 is a cross sectional view of a single substrate ALD chamber in accordance with an alternative embodiment.

Fig. 6 is an enlarged view of the nonsealing flow restrictor of Fig. 5.

[0016] ~~Fig. 2 illustrates~~ Figures 2A and 2B illustrate in schematic form a typical process 120 for depositing material on to a substrate such as the substrate 108 using the chamber 100. As explained in greater detail below, the present inventions have particular applicability to deposition processes such as atomic layer depositions in which many very thin layers are deposited in rapid succession onto the substrate. As indicated generally at 122, a typical process is initiated by admitting a substrate into the

chamber though a slit valve or other suitable substrate port 124 (Fig. 1) and onto the support surface 106 for processing. A heater 128 may be provided within the substrate support 102 to heat the substrate 108, depending upon the particular deposition process.

[0019] For example, prior to admitting or during the admission of deposition gas, the exhaust flow restrictor 154 may be closed (step 170 of ~~Fig. 2~~ Figs. 2A and 2B) to facilitate achieving an adequate deposition gas pressurization level in the chamber during the deposition process. As indicated at 172 in ~~Fig. 2~~ Figs. 2A and 2B, the closing of the exhaust flow restrictor 154 initiates a "pressure cycle" in which the pressure of the chamber is increased for deposition. Thus, following closing of the exhaust flow restrictor 154 a processing gas such as a deposition gas is admitted (or continued to be admitted) into the chamber through the gas inlet 140 as represented by step 173 in the process of ~~Fig. 2~~ Figs 2A and 2B. Because the flow restrictor 154 is closed, the pressure in the chamber will rise. However, because the exhaust flow restrictor 154 in the embodiment of Fig. 1 is not a sealing type flow restrictor, it is anticipated that some deposition gas may escape through the closed flow restrictor 154 during the deposition process. However, as long as the flow rate through the closed flow restrictor 154 is less than the flow rate through the inlet flow valve 141, it is believed that the pressure in the chamber can rise to the desired level notwithstanding leakage through the exhaust flow restrictor 154. In a preferred embodiment, the flow rate through the closed flow restrictor is within a range of 0 – 100 sccm (standard cubic centimeter per minute) at a pressure in the range of 10 Torr to 300 Torr. Thus, the flow restrictor can be a near sealing flow restrictor which has a relatively low flow rate in the "closed" position.

[0020] Once the desired pressure level has been achieved, the flow valve of the deposition gas inlet 140 may be closed. For some deposition processes, it may be desirable to permit the substrate 108 to soak in the deposition gas atmosphere (step 174, ~~Fig. 2~~ Figs. 2A and 2B) in the interior of the chamber for a length of time following

the closing of the gas inlet to ensure an adequate deposition thickness. To ensure adequate deposition gas pressure during the soaking period, the deposition gas pressure may be raised prior to closing the gas inlet to a level which would accommodate some leakage through the exhaust flow restrictor during the soaking period. In one embodiment, the pressure may rise to a level of 300 Torr, for example. Thus, although the deposition gas pressure may fall somewhat during the soaking period because of some leakage through the nonsealing exhaust flow restrictor, the deposition gas pressure at the end of the soaking period may still be sufficiently high to ensure a satisfactory deposition. In a preferred embodiment, the deposition gas pressure for a typical deposition gas may fall to a level in a range of 5 – 30 Torr.

[0022] Once the substrate has soaked in the deposition gas for a sufficient length of time to deposit the desired thickness of deposition material, the pressure cycle 172 may be ended by opening the exhaust flow restrictor 154 (step 180, ~~Fig. 2~~ Figs. 2A and 2B) as shown in Fig. 1 to permit the residue gasses to be readily exhausted from the chamber interior during a "purge cycle" as indicated at 182 in ~~Fig. 2~~ Figs. 2A and 2B. In this open position, the exhaust flow restrictor 154 preferably has sufficient conductance to permit rapid exhaustion of the residue gasses. In a preferred embodiment, the non-sealing flow restrictor 154 has a conductance in the range of 10 – 20 slm (standard liter per minute) in the open position. By comparison, the conductance of the near sealing flow restrictor 154 in the closed position illustrated in ~~Fig. 2~~ Figs. 2A and 2B is preferably much smaller and is preferably close to zero but it is anticipated that the conductance will be somewhat greater than zero because the flow restrictor is a non-sealing flow restrictor. In a preferred embodiment, the near sealing flow restrictor 154 has a conductance in the range of 0 - 100 sccm in the closed position.

[0023] To facilitate exhausting the residue gasses from the chamber, a pump 200 may be coupled to an outlet port 202 of the exhaust outlet 150 as shown in Fig. 4. In addition one or more purge gasses may be admitted into the chamber as indicated in step 204 (~~Fig. 2~~ Figs. 2A and 2B), to drive the residue gas from the chamber interior as the pump

200 pumps the gasses through the exhaust flow restrictor 154, through the exhaust passageway 152 and out of the chamber through the outlet port 202. Once the chamber has been sufficiently purged, a different reactant or deposition gas may be admitted to deposit another thin layer.

[0024] In the process of ~~Fig. 2~~ Figs. 2A and 2B, there is a plurality of pressure cycles 172, each followed by a purge cycle 182, to sequentially deposit a plurality of layers onto a substrate before the substrate is removed from the chamber. In each pressure cycle 172, the non-sealing flow restrictor 154 is closed and a process gas such as a deposition gas is admitted. After a layer has been deposited, the non-sealing flow restrictor is opened and residue gasses are discharged in the subsequent purge cycle 182. The process gas or gasses may be the same in each pressure cycle or may change, depending upon the desired process.

[0025] In the embodiment of ~~Fig. 2~~ Figs. 2A and 2B, a first reactant gas is admitted in the gas admission step 173 of the first pressure cycle 172. After the subsequent purge cycle 182, a pressure cycle 206 follows which is similar to the pressure cycle 172 except that following the closing of the exhaust flow restrictor (step 208) a second, different reactant gas is admitted in an admission step 210 of this next pressure cycle 206. During the pressure cycle 206, the second reactant is deposited onto or otherwise reacts with the first reactant deposited in the prior pressure cycle 172 (step 212) to form another thin layer on the substrate. Examples of deposition materials in a second pressure cycle include nitrogen, oxygen or silicon which can react with the previously deposited material to form a nitride, oxide or silicide, respectively.

[0026] Following each pressure cycle 206, a purge cycle 214 similar to the purge cycle 182, opens the non-sealing exhaust flow restrictor 154 (step 216) to purge the undeposited second reactant from the chamber using a purge gas (step 218). The pressure cycles 172 and 206 alternate in this manner, depositing alternating layers of the first and second reactants, each pressure cycle being followed by an associated

purge cycle 182, 214, until the desired film thickness has been deposited (or the film processing is otherwise complete). After the final purge cycle 214, the slit valve 124 is opened and the substrate is removed from the chamber as shown in step 220 of ~~Fig. 2~~ Figs. 2A and 2B. Because of the rapid opening and closing capabilities of the flow restrictor 154, it is believed that the combined total of the pressure cycle and the purge cycle may be in a range of 5 - 20 seconds and more typically 10 seconds for many applications. However, the exhaust flow restrictor is suitable for substantially shorter cycles of .5 seconds or less, depending upon the application. Other pressure cycles may be 5 seconds or 3 seconds or less, depending upon the application.

In the claims:

No claims are amended at this time.

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